



**University
of Victoria**

Graduate Studies

Notice of the Final Oral Examination
for the Degree of Doctor of Philosophy

of

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**“Modelling Sea-Ice and Oceanic Dimethylsulfide Production
and Emissions in the Arctic”**

School of Earth and Ocean Sciences

Thursday, October 18, 2018

8:00 A.M.

Clearihue Building

Room B017

Supervisory Committee:

Dr. Nadja Steiner, School of Earth and Ocean Sciences, University of Victoria (Co-Supervisor)

Dr. Adam Mohanan, School of Earth and Ocean Science, UVic (Co-Supervisor)

Dr. James Christian, School of Earth and Ocean Sciences, Uvic (Member)

Dr. Ann-Lise Norman, Environmental Science Program, University of Calgary (Outside Member)

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Dr. Sergio Vallina, Senior Researcher, Spanish Institute of Oceanography

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Dr. Slim Ibrahim, Department of Mathematics and Statistics, UVic

Abstract

Recent field observations suggest that the radiative forcing of aerosol and clouds in the Arctic may be seasonally regulated by the oceanic emissions of the climatically-important biogenic trace gas dimethylsulfide (DMS). However, the validity of the proposed argument is challenged by the limited spatio-temporal coverage of these earlier studies in this difficult-to-access region. In particular, little is known about the pan-Arctic distribution of the oceanic DMS emissions, its temporal variability, and the impacts of sea-ice biogeochemistry on these emissions. In this dissertation, I investigated these unexplored subjects through numerical modelling. Using a one-dimensional (1-D) column modelling framework, I developed a coupled sea ice-ocean biogeochemical model and assessed the impacts of bottom-ice algae ecosystems on the underlying pelagic ecosystems and the associated production and emissions of DMS. The model was calibrated by time-series measurements of snow and melt-pond depth, ice thickness, bottom-ice and under-ice concentrations of chlorophyll- α and dimethylsulfoniopropionate (DMSP), and under-ice irradiance obtained on the first-year landfast sea ice in Resolute Passage during May-June of 2010. Many of the model parameters for the DMSP and DMS production and removal processes were derived from recent field measurements in the Arctic, which is advantageous over the previous Arctic-focused DMS model studies as their model parameters were based on the measurements in extra-polar regions. The impacts of sea-ice biogeochemistry on the DMS production in the underlying water column and its potential emissions into the overlying atmosphere were quantified through sensitivity experiments. To extend the study domain to the pan-Arctic, I implemented the sea-ice ecosystem and the coupled sea ice-pelagic DMS cycling components of the 1-D column model into a three-dimensional (3-D) regional modelling framework. A multi-decadal model simulation was performed over the period 1969-2015 using realistic atmospheric forcing and lateral boundary conditions. The results of the simulation were evaluated by direct comparisons with available data products and reported values based on field and satellite measurements and other model simulations. These comparisons indicated that my model reasonably simulated the decline of Arctic sea ice, the magnitude of the pan-Arctic sea-ice and pelagic annual primary production and their general spatial patterns, and the mean seasonal cycle and the spatial distribution of the surface seawater DMS climatology within the pan-Arctic. However, at the same time, the comparison of the DMS climatologies was challenged by the bias in the *in situ* measurement-based climatology, emphasizing the need to update this data product, which was created almost a decade ago, by incorporating data acquired during the recent field campaigns. The analysis of the modelled fluxes of DMS at the ice-sea and sea-air interfaces revealed different responses to the accelerated decline of sea ice over the recent decades (1996-2015). It is concluded that further model development and coupling efforts are needed to better address the climate change impacts on oceanic DMS emissions, and, in turn, their influence on the Arctic climate.